WORKSHOP ON SMALL-SCALE FOOD PROCESSING CONTRIBUTING TO FOOD SECURITY

Small-scale agroprocessing: three case studies

George Breag, Richard Marder, Alan Marter and Tony Swetman

Background

Agro-processing in developing countries

Agroprocessing is of major importance in most developing countries and in the majority of sub- Saharan Africa between one and two-thirds of value-added manufacturing is based on agricultural raw materials. (Jaffee and Morton ,1995). Technology development (TD), can contribute to the growth of agroprocessing which in turn plays a major role in generating value added to agricultural raw materials. With careful targeting and the involvement of likely users of the technology, TD can be effective in the generation of livelihoods for poorer communities.

What is technology development

TD is defined here (after Appleton, 1993) as any change in skills, techniques, processes, equipment, type or organisation of production which helps people to cope with, or take advantage of particular circumstances. It therefore encompasses all aspects of technology transfer.

Constraints

It may often be most effective to leave TD to the private sector. However, in developing countries there are a number of constraints which may inhibit private sector activity, and which may therefore imply a role for government and/or donor agency activity. These constraints include:

- indigenous inventors may not have the technical and financial resources to withstand the risks of new product development;
- whilst the female work force may represent a good market for technologies, cultural and institutional constraints may create barriers to realising market potential;
- inadequate flows of information between and within developing countries may limit the capacity to upgrade technology;
- resources and technical skills may be lacking that are required in order to adapt technologies that have been developed to suit conditions in Northern economies;
- the private sector is reluctant to take up opportunities whose profit margins are modest, and or where markets are distant; and,
- the private sector may face difficulties in convincing credit agencies of the viability of the enterprise.

The above are drawn on firsthand experience of the authors and include adaptations of Jeans et al . (1991).

Although there is a case for TD supported by government and/or donor activity, the achievements of such interventions have often been modest. Experience suggests that limited success in TD may arise from a number of factors - the constrained resources available in developing countries; the failure to use , or use effectively, tools required in the TD process (eg technology adaptation, market assessment, financial appraisal etc); and the characteristics of government and/or donor bodies. The time scale for effective TD may often have been underestimated, and donor or government policies may change, to the possible detriment of ongoing TD programmes.

The following case studies illustrate that careful application of appropriate tools and support can result in successful TD initiatives. The focus is upon relatively low cost technologies targeted upon poorer communities, with a specific emphasis upon women.

Case Studies on small-scale agroprocessing operations

Persimmon drying in Pakistan

This project involved the development and evaluation of suitable methodologies for drying persimmon fruit to test the feasibility of small-scale and larger scale commercial production through on-farm research trials. Three methods were evaluated: raised trays , a solar box and permanent larger scale brick-built solar dryer.

The fruit, cultivation and traditional processing.

Persimmon originates in China and is referred to as the "apple of the orient". There are 400 species, of which the most important is Diospyros kaki , commonly known as the Japanese persimmon or kaki. The fruits vary in shape and colour and are classified broadly into two major groups: non-astringent and astringent varieties.

In Pakistan D. kaki is cultivated primarily in the North-West Frontier Province (NWFP), mostly in Malakand, Peshawar and Mardan Divisions with the Swat District being the major production area (Table 1). It was introduced to the region 20-30 years ago and the majority of varieties found are astringent, have a dry and bitter taste until they ripen. When fully mature the fruit has a tough, glossy orange -red skin and a yellow -orange flesh which is sweet and juicy.

Table 1. Persimmon production in the Malakand Division.

District	Area (ha)	Production (t)
Malakand Agency	87	689
Swat	242	3 060
Dir	63	507
Chitral	2	24
Malakand Division	394	4 280
Peshawar Division	-	3 120
Mardan Division	-	1 043

Source: NWFP Agricultural Statistics 1989-90

The fruit is grown in orchards or as garden fruit, where the bulk is consumed in the home. The largest orchards are 6 ha (with 500-800 trees), generally managed by tenant farmers, but smaller orchards of 1-2 ha (50-150 trees) are often owned by farmers. The majority of the larger scale farmers sell the product on

a contract basis. The contractor harvests, packages and sells the crop. Some smaller scale farmers harvest and sell the fruit themselves at the local market, if a good price cannot be obtained from the contractor. Often large quantities of fruit are wasted at the time of harvest due their abundance and short shelf-life. (Marder, R. C. and Schoemaker, A , 1993) .

In China and Japan persimmon is sun dried on a large scale by hanging bunches from bamboo poles after sulphur dioxide treatment. (Kitagawa and Glucina 1984; Sweedman 1989). In Pakistan, persimmon has not been dried in the past, however many other fruits and vegetables, particularly apricots, are traditionally dried, particularly at household level for storage and future use during winter months. These food preservation activities are primarily the responsibility of women.

Collaborators

The project was undertaken in close collaboration with the Malakand Fruit and Vegetable Development Project, the Agricultural Research Station, North Mingora, the Fruit and Vegetable Development Board Women's Programme and last, but most importantly, with groups of farmers and women. The Natural Resources Institute's involvement as technical and development advisers was through a contract with Intercooperation.

On-farm Trials

Trials were conducted at selected sites, including:

- A large farm with an orchard of 200 trees. The farmer usually sold the fruit on a contract basis.
- A small farm with an orchard of 40-50 trees. The farmer occasionally sold his fruit on a contract basis but normal practice was to harvest and sell the fruit himself through the local markets or his own shop.
- The home of a female householder selected with the assistance of the Fruit & Vegetable Development Board.

Three methods were tested and evaluated and a simple financial analysis completed for each of the methods - sundrying on raised tray, small scale solar drying in a wooden box, and large scale solar drying in a specially constructed brick dryer. The method of production recommended was:

- to harvest (the fruit when they are under-ripe, almost fully yellow with a slightly green colour, but still firm);
- to wash, peel and cut it laterally;
- to pre-treat it with a solution of metabisulphite to maintain a good appearance; and then
- to dry the fruit.

All three methods employed proved technically and financially feasible and have been adopted at pilot scale by various farmer and household groups. However the small solar box was found to be particularly suited to household production, producing a good quality sweet product, and offering good protection from rain, dust and insects.

The alternative to drying fruit is to sell fresh persimmons. To cover the equivalent value of fresh fruit sales would require minimum prices of 21, 26 and 27 rupees per kg of dried product for each drying method respectively (Table 2).

The appropriate pricing niche for dried persimmons is considered around that for apricots. The relative prices derived from the alternative drying technologies compared to wholesale price levels for apricots (Table 3), indicate that a feasible market opportunity exists.

Initial market testing was conducted by distributing suitably packaged samples of approximately 200 g throughout the dried fruit markets and shops in Islamabad, Rawalpindi and Peshawar. These were met with encouraging interest and optimism with regards the sale in local markets with traders and shopkeepers alike confident they could sell the product. On the consumer side most people actually expressed a preference for the dried fruit over the fresh persimmon. Further marketing activities have established a number of retail outlets for the product.

Case (a) Conclusions

Apart from the technical and financial viability which was demonstrated through the execution of a carefully planned programme of work, the principal ingredients for the successful adoption of the technology were a clearly identified need, an established market infrastructure which was already trading in dry fruits, selection of a simple and reliable method of production maximising the use of locally available materials of construction, an excellent local collaborating organisation with a strong extension service and commitment to succeed.

Small-scale solar drying in Uganda

Having identified a niche market in the United Kingdom for dried fruit and vegetables, suitable methodologies for drying of fruit were developed and tested through on-farm research trials. Subsequently a core of farmer groups were trained in commercial fruit drying operations and the production of items for export from Uganda to the UK market.

Drying fruit, a real need

In Uganda, surplus fruits and vegetables can be dried to reduce waste and provide a means of additional income for farmers. Although there are several methods of preservation - canning, freezing and artificial drying - simple drying techniques are the most appropriate for application in rural farming areas which have limited technical, financial and management resources (Anon., 1993). Scope and need for the application of simple solar dryers was identified and an NRI-modified solar cabinet dryer was built locally.

Collaborators

The work undertaken by NRI was in close collaboration with the Fruits of the Nile (U) Ltd, the Kawanda Agricultural Research Institute, and the principal project participants - the dryer groups - which subsequently formed the team which provided dried product for sale. Inputs were also made by various NGOs and Government Departments .

On-farm Trials

Following an NRI technical, financial and socio-economic evaluation of locally built dryers introduced by the Fruits of the Nile and the Kawanda Agricultural Research Station, modifications were made to the existing systems which doubled throughput and consistently produced good quality fruit and vegetables. The type of dryer used is shown in Figure 2 and was successfully adopted by the drying groups for the manufacture of dried sliced pineapples, bananas, mangoes, tomatoes and mushrooms.

Table 2. Persimmon drying costs.

Method	Raised rack	Wooden box	Brick dryer
Throughput (kg)	100.0	140.0	1 500.0
Fresh peeled fruit	25.0	35.0	375.0
Dried fruit yield			
Capital costs (Rupees)	310.0	1 260.0	15 100.0
Investment	62.0	252.0	3 020.0
Capital/cost/year			
Variable cost per year (Rupees)	150.0	210.0	2 250.0
Preparation	150.0	210.0	2 250.0
Pretreatment			
Production cost per year (Rupees)	362.0	672.0	7 520.0
Total	14.5	19.2	20.1
Per kg dried fruit			
Farmgate price for fresh fruit (Rupees)	82.5	115.5	1 155.0
Farmers earnings	6.6	6.6	6.6
Dry fruit equivalent			
Break-even price of dried fruit (Rupees)	21.1	25.8	26.7

Rates of exchange at time of analysis = Rupees 26 per US $.

The analysis was based on an investment period of 5-years and a persimmon harvest and drying season of 2 months. Potentially the drying system could be operated to preserve different products, increasing utilisation with a commensurate cost saving.

Market Analysis

The wholesale prices of dried fruits (in rupees per kilogram) within the major market towns were as detailed in Table 3.

Table 3. Wholesale and retail dried fruit prices in Pakistan, October 1992.

Product	Wholesale Price	Retail Price
Apricots		
Afghan	32	NA
Local	28	108
Dates	18	40
Figs	32	108
Raisins	40	120
Plums	35	120

(Marder, RC. and Schoemaker, A., 1993)

The work was conducted by drying groups, mostly household and women's groups, who were ideally suited to this kind of small-scale income generation activity. The participants were selected by local organisations in consultation with the Fruits of the Nile.

Financial Analysis

The financial analysis of the four systems for drying pineapples as a base case is given below (Table 4). Four dryers were evaluated: a Fruits of the Nile (FON) dryer; a Kawanda cabinet dryer;; a chamber and chimney dryer; and an NRI modified Kawanda cabinet dryer..

Table 4. Summary of financial and sensitivity analysis for the four dryers.

	FON Cabinet '000s	Kawanda Cabinet '000s	Chamber & Chimney '000s	NRI modified Cabinet '000s
Capital	277.0	153.2	3 761.9	390.0
Life yrs	5	5	15	5
Base case				
NPV	115. 5	-40.9	-675.0	224.9
IRR (%)	25			30
Payback yrs	3			3
Sensitivity analysis				
Drying Capacity (increasing quantity of fresh fruit loaded onto drying trays) + 25%				
NPV	377.9	63.9	1 427.9	624.9
IRR (%)	55	25	13	63
Fresh fruit price - 25%				
NPV	254.6	-16.9	439.2	456.3
IRR (%)	42	12		50
Fresh fruit price + 50%				
NPV	-161.5	-156.6	-2 903.5	-237.9
Transport cost x 4				
NPV	- 20.5	-177.4		88.5
IRR				18
Capital cost - 25%				
NPV	179.2	-5.1	315.1	312.4
IRR (%)	39		12	44
Payback yrs	2		8	2

Note: All costs are given in USh (Ugandan Shillings)

The analysis shows that for the base case costing, and for most of the sensitivity analyses applied, the original Kawanda cabinet dryer has a negative NPV, indicating that it is unlikely to be financially viable under most circumstances. The other dryers all had positive NPVs under the base case costing, with the NRI modified Kawanda dryer having the highest IRR. The reason for this was that the capacity of the dryer was doubled at a small additional cost. As shown in the sensitivity analysis, increasing the capacity

of the dryer i.e. loading of fresh fruit on the dryer trays, can significantly improve viability. All the dryers have a long payback period (3 years), although this is reduced if capital costs are lower.

Market Prices and transport of dried fruit

The sensitivity analyses above clearly indicate the impact of fresh fruit prices on the viability of drying operations. Location of drying capacity within the major fruit producing areas provides two distinct advantages. First the price of fruit is lower in such areas and second it is less subject to seasonal fluctuations. An indicator of price differentials in 1994 is that pineapple prices in Kampala were 50% above those in the major growing area, Kayunga.

Transport costs of dried fruit to FON in Kampala also have some impact on viability. However, as shown in the sensitivity analysis, even a very substantial increase in transport costs (by a factor of 4), still produces a positive NPV for the NRI modified drier.

Case (b) Conclusions

The lessons learnt from this study was that whilst the infrastructure, enterprise network and strong incentive was in place the business would not have moved ahead with the success it has experienced without recognition from FON business manager that the dryer units and methodology of preparing the product needed to be optimised. A detailed techno-socio-economic evaluation coupled with the strong desire of the participants to make their venture profitable enabled the findings of the study to bring important operational and financial aspects into focus.

Profitability will depend on a number of factors but a key item will be the utilisation rate of the dryer. In practice, the small Cabinet dryers proved to be easy to use with a much higher utilisation level compared to the larger chamber dryers. The latter point emphasises the importance of keeping technical innovations as simple as possible when targeting poorer groups of rural processors.

Since the initiation of the project sales of product in the UK market has more than doubled to 4 tonnes per annum. Although the overall UK market for dried fruit and vegetable products is stagnant (Anon, 1994), its sheer scale (in excess of 500 tonnes per annum), means that Ugandan exports can continue to grow via expansion of market share. Further growth will therefore depend on continuing price competitiveness and attention to quality requirements for the specific fruits and vegetables supplied. From the outset the project has incorporated a careful analysis of marketing options (a component all too often overlooked in TD projects), and there are grounds for optimism over future expansion in exports.

Household coconut processing in Tanzania

Household-level processing is an important source of edible oil in Africa. The traditional processes involved tend to be labour-intensive, arduous, poorly remunerative and, sometimes, inefficient in oil extraction. This type of activity is conducted exclusively by women, for whom it represents an important source of income and household consumption. Yet a significant concentration of effort on the development of "appropriate technologies" has resulted in a marked lack of uptake of such technologies by women. The philosophy underlying the work described here is that women's needs can only be addressed if women's participation is an integral part of technology identification and development. Implicit in this is a rigorous iterative process of field test, feedback, modification and re-test.

The approach

Coconut processing was the focus of research and development undertaken by NRI in collaboration with the National Coconut Development Programme (NCDP) in Tanzania. Home production of coconut milk (which is oil-rich) and oil was estimated to account for 50% of Tanzania's domestic supplies of oil. The estimated one million women engaged in this activity have very limited funds to invest in improved equipment, and rarely have access to electricity.

A participatory approach to step-wise improvements in existing oilseeds processing methods was judged most likely to identify and promote improvements in the traditional coconut process that would be acceptable to the target groups, even if such improvements were modest in engineering terms.

The traditional process

The traditional coconut grater used in Tanzania is known as an "Mbuzi" and consists of a fixed grater blade mounted on a stool. The operator sits on the stool and rubs half coconut kernels still in the shell against the blade. The gratings are squeezed by hand, with water, 3-4 times. The resultant milk is left to stand to allow some separation of the oil and water, with the oily cream then skimmed off and boiled to get rid of the remaining water.

The women found the grating arduous and time-consuming, and it gave them chest pains. Some complained about the squeezing process too. The income generated was important, but they would have preferred to sell their oil at high off-season prices, but this is prevented by the need for immediate income, and deterioration of oil during storage. Moreover, the traditional process only extracts about 60% of the available oil.

Scope for improvements

These were identified as: making the grating operation less arduous; more efficient pressing methods to replace manual squeezing of coconut/water mixtures; further processing to produce oil from the coconut residue; and improved oil storage.

Field trials

Graters - Various grater types (stirrup operated, cycle operated, and a table-mounted rotary grater) were tried by women in selected villages, and feedback obtained from group meetings. In close consultation with the women processors the design of a six-bladed rotary grater was introduced to Pande and Madanga villages, Tanga Area, Northern Tanzania. Oil yields were 8-20% higher (because the grater yielded finer gratings which contributed to more efficient oil extraction) and the grating speeds were 1.6-3.3 times faster. All women interviewed expressed preference to the rotary grater explaining that it was less arduous to use and that it did not give chest and back pains associated with traditional grating.

Table 5. Illustration of potential financial benefit from use of rotary grater.

Coconut price	20	Tsh/nut
Oil price	400	Tsh/litre
Batch size	12	nuts
Mbuzi oil yield	0.75	litres/batch

Rotary grater yield increase = over 10%

Returns per batch.

Mbuzi	60	Tsh
Rotary	90	Tsh

The cost of the grater is about UK£5. Efforts are now focused on the encouragement of more widespread private manufacture and distribution, and the availability of merchant credit to women for purchase of the graters.

Storage - Although consideration was given to low cost means of improving storage (storage in clean dry bottles, in a cool dark place), for most processors, the main constraint to this is the need for immediate income. As a consequence, a decision was taken not focus on this aspect of the process.

More efficient pressing methods to replace manual squeezing - Very little work was done on this aspect of the process, because preliminary research indicated that the cost of innovative technology in this area, was likely to be too expensive for the target group.

Ram presses - Women's groups (Rziki Kwa Mungu Group and Kiduni Women's Group, both on Zanzibar) were involved in the testing of ram presses to extract the oil from dried pressed coconut gratings called "machicha". The presses were built locally by the Centre for Agricultural Mechanisation and Rural Technology (CAMARTEC), and NGOs were seeking to introduce the presses to women's groups, as an incoming generating activity. The machicha in Tanzania is mostly discarded and eaten by poultry, although there is an intermittent and small demand for gratings, for oil extraction using expellers (for soap manufacture, since the oil from the old, dirty gratings would be rancid).

Using figures for throughput (4kg machicha/ hour) and oil recovery (37%), based on field trials with women's groups, 1 litre of oil per hour can be obtained.

Assuming that the ram press would only be operated for 4 hours per day, although higher levels of operation would not be unreasonable, Table 6 summarises the potential financial benefits from ram press operation, using field data obtained in January 1995.

Table 6. Illustration of potential benefits from using the ram press.

Cost of ram press in Zanzibar: 68,000 Tsh

Machicha	4.0	kg/h
Oil yield	0.37	kg oil/kg machicha
Operation	4.0	h/day
Machicha oil price	400	Tsh/litre
Machicha price	25	Tsh/kg

Payback periods:

Assuming free machicha and labour donated by women's group	29 days
Assuming machicha @ 25 Tsh per kg and labour donated by women's group	35 days

Case (c) Conclusions

It was concluded that the real participation of the user groups was key to the development and subsequent adoption of the technology. The iterative approach of field trial, monitoring and modification allowed the women's concerns to be addressed, and permitted the development of technologies appropriate to the resources and constraints they face.

Additionally private workshops were involved from the outset, and as the project progressed, the workshops interacted directly with potential clients and NCDP's role diminished.

Steps are now being taken to disseminate the findings through a project entitled "Improving small-scale extraction of coconut oil" which involves collaborators from Cote d'Ivoire, Ghana, Tanzania, India, Sri Lanka and Indonesia. The Asian Pacific Coconut Community and the African Oil Palm Association are to be involved in dissemination within the Asia Pacific and African regions respectively.

Overall Conclusions

The importance of careful targeting, assessment of financial viability, and scope for marketing of outputs are all evident in the case studies. Whilst these requirements are obvious enough, they are often overlooked in TD projects. An important component in project design is the establishment of clear and effective monitoring systems that produce a flexible approach - allowing modifications to be made (for example in response to hardware problems) or adapting to changing external circumstances (for example changes in government policy or demands for more stringent product standards). The most important ingredient for success is the close involvement of potential users of technology from the start within the TD process.

On the basis of firsthand experience of a number of commercially-oriented projects it is clear that many would benefit from access to both technical and financial advice and assistance. Unfortunately this is not often available, especially for the poorer sectors such as artisanal food processing enterprises which are often operated by women in both urban and rural areas. This emphasises the importance of effective dissemination strategies that can maximise the impact of any given TD initiative.

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FON dryer

NRI (modified Kawanda) dryer

Sundrying persimmon on a raised tray

Grater head of traditional Mbuzi

Rotary grater mounted on traditional stool

Ram press in operation

Rotary grater in operation